
**Imaging materials and prints —
Abrasion resistance —**

**Part 1:
General rub testing methods**

*Matériaux pour l'image et les impressions — Résistance à
l'abrasion —*

Partie 1: Méthodes d'essai de frottement générales

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 42, *Photography*, in cooperation with ISO/TC 130, *Graphic Technology* and ISO/IEC JTC 1/SC 28, *Office equipment*.

This second edition cancels and replaces the first edition (ISO 18947:2013), which has been technically revised. The main changes compared to the previous edition are as follows:

- graphic prints and office prints are also covered,
- more test devices have been introduced,
- visual evaluation was added.

A list of all parts in the ISO 18947 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This method is one of a series relating to permanence and durability of image prints, which is the resistance to physical, mechanical, chemical and/or environmental stresses in conditions of use. The permanence of the image under environmental stresses is tested by each stress factor individually: light (ISO 18937^[11]), heat (ISO 18936^[10]), ozone (ISO 18941^[12]), and humidity (ISO 18946^[13]). These stress factors are given by the ambient conditions, over which the user often has limited control. The exposure to mechanical and physical stress may often be controlled by the user, unless intense handling is integral to intended use. Tests for rubbing of prints resulting in abrasion or smearing of the image are handled in the series 18947, scratch resistance is addressed in ISO 18922^[8] (for film) and in the series ISO 18951 (all parts) (for reflection prints, currently under development), respectively, and durability tests to simulate accidental exposure to water or food spill is described ISO 18935^[9].

The process of rubbing a surface may result in different types of degradations, e.g. abrasion, scuffing, smudging, and others. They may be observed as loss of colour intensity, scratches, changes in gloss, coloration of former uncoloured areas, (coloured) material transfer to a receptor and others.

This document provides standardized requirements to evaluate the abrasion resistance of image prints in their various formats.

Abrasion and smudge can include both accidental and repeating stresses resulting from handling of the image. The following are some examples of sources of abrasions:

- dirt particles rubbing on printed surface;
- sheet-to-sheet abrasion (sliding motion of sheets relative to each other);
- prints sliding on tables or other flat surfaces;
- interaction with dirt or components inside of printers;
- magnets or other items used in the display of images.

This second edition transforms ISO 18947 into a multipart standard to extend the applicability of this standard to analogue and digital photographic, graphic and office prints. In addition, this second edition allows for the use of additional types of rub testers. The level of abrasion observed in a test depends on the combination of many factors, including factors of the print material under test as well as the test apparatus.

Different test devices show different levels of rub work, depending on the force of the device, relative movement of the samples (direction and speed), test length on the device and the selection of the material and geometry of the abrading receptor.

Material factors that contribute to friction coefficients and therefore influence the susceptibility of printed image to abrasive conditions include surface roughness, surface elasticity, substrate porosity of samples and the chemical formulation, mobility as well as localization of the colorants on the surface or within a receiver layer.

A research project^[23] performed to develop content for the expansion of the applicability of this standard to prints of all kinds tried to link the magnitude of abrasion to a combination of surface roughness, surface elasticity, substrate porosity, direction of the paper fibres and ingredients of inks. The samples used were black sheet-fed offset prints. Substrates, prints and tested samples were investigated with respect to the mentioned properties. Receptors were investigated with respect to the degree of material transfer using scanning densitometry, colour measurement using diffuse sample illumination and two different scanner based image analysis systems. Unfortunately, no correlation of the optical measurements to the visual assessments could be established. This is the background that this document also requires visual assessments of rub sample series.

For photographic prints on coated photo-grade papers, a correlation between abrasion results on reciprocating, flat abrasion testers was found in a round robin study (several laboratories tested

samples of the same origin) of TC 42/WG 5, that included imaging technologies such as silver halide, inkjet, electro-photographic and dye diffuse thermal transfer. Together with results from IPI^[22] this round robin study serves as background for ISO 18947-2, which is dedicated to (quasi-) linear, reciprocating, abrasion testing of photographic prints on photo-grade papers, including resin coated (RC photo-grade), barrier coated (water impermeable) paper and coated (water permeable) paper, as well as photo-grade films. The term (quasi-)linear considers that the test movement on the Sutherland type tester (see [A.1](#)) follows an arc segment of a circle with a large diameter, resulting in a mainly linear motion with a small orthogonal component.

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Imaging materials and prints — Abrasion resistance —

Part 1: General rub testing methods

1 Scope

This document specifies test methods to determine the rub resistance of analogue and digital prints. This includes photographic as well as graphic and office prints on all substrates. ISO 18947-1 provides information and general guidance relevant to the selection and operation of abrasion test methods and also describes general performance requirements for abrasion test devices used.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2813, *Paints and varnishes — Determination of gloss value at 20°, 60° and 85°*

ISO 2834 (all parts), *Graphic technology — Laboratory preparation of test prints*

ISO 8254-1, *Paper and board — Measurement of specular gloss — Part 1: 75 degree gloss with a converging beam, TAPPI method*

ISO 18947-2, *Imaging materials and prints — Abrasion resistance — Part 2: Rub testing of photographic prints*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 abrasion

loss of material from a surface or deformation of a surface, with changes in gloss, colour, or density, due to frictional forces as a result of rubbing

Note 1 to entry: Surface deformations can result in changes in gloss and colour.

3.2 analogue print

print, where the image is printed from the analogue domain

Note 1 to entry: In graphic printing, the marking information of an analogue print is generated by means of an off-line produced forme with which the ink is printed on the media. Examples of traditional forme-based printing as defined in ISO 12637-1 are flexographic, letterpress, letterset, (offset) lithographic, gravure, intaglio, pad-transfer printing, screen and stencil printing.

Note 2 to entry: Ambiguous use also for chromogenic (silver-halide) print, where image information is exposed conventionally (“analogue”) through a film negative or positive, or actual scene images are exposed through camera lenses.

3.3 digital print

print where the image is printed directly from the digital domain

Note 1 to entry: Digital print is a print made directly from digital data when there is no intermediate image carrier, or when the image carrier is refreshed for each impression and thus each impression can be different in content if desired.

Note 2 to entry: Graphic printing in its various forms as defined in the ISO 12647 (all parts) is typically categorized as “analogue printing” even though data may stem from the digital domain as in the case of computer-to-plate systems.

Note 3 to entry: There is substantial confusion around the definition of this term by users, particularly in the consumer market where it may be taken to mean a print where the original image is produced or manipulated in the digital domain.

3.4 interval scale

<psychophysical> scale established by a psychophysical method, which, in addition to possessing the attributes of *rank order* (3.7), is distinguished by the fact that equal differences between numerical values correspond to equal differences between properties measured (in sensory analysis, perceived intensities)

Note 1 to entry: Larger values correspond to larger perceived intensities and the size of the difference between two values reflects the size of the difference in perceived intensity of the property being measured. However, a numerical value of zero may not indicate a total absence of the property and the ratio of two values cannot be assumed to reflect the ratio of the perceived intensities.

3.5 minimum density

$D_{\min}$
optical density corresponding to the maximum transmittance (film) or reflectance (paper) that a printed product can achieve

Note 1 to entry: The representation of the minimum density level of a print depends on the printing technology and includes (a) non-printed area of the print material, i.e. a substrate with or without a specific image receiving or image forming layer, (b) coated or printed pre-white area (wherein a white layer is applied before the image is printed such that a coloured or transparent substrate is covered) or (c) a printed area of the material, where a transparent and/or white process colour (e.g. ink or toner) is printed image-wise.

Note 2 to entry: In this document, transparent substrates are evaluated in reflection mode by use of a white or black backing, as suitable.

[SOURCE: ISO 12641-2:2019, 3.6, narrowed to prints observed in reflection mode]

3.6 quasi-linear

<materials testing> curvilinear motion with a small component of total displacement orthogonal to its main movement

Note 1 to entry: The Sutherland type abrasion tester provides an arc motion, where the length of the arc is much shorter than the radius of the circle, resulting in a mainly linear motion with a small orthogonal component. The Martindale type tester using a Lissajous-Figure as the rub schema also has a mainly linear motion with a small orthogonal component.

3.7**rank order**

result of a psychophysical method involving the arrangement by an observer of a series of stimuli in order of increasing or decreasing image quality or an attribute thereof, in accordance with the set of instructions provided

3.8**ratio scale**

<psychophysical> scale established by a psychophysical method, which has the properties of an *interval scale* (3.4) but for which, in addition, the ratio between the values allocated to the two stimuli is equal to the ratio between the perceived intensities of these stimuli

Note 1 to entry: With this scale, a numerical value of zero designates total absence of the property.

Note 2 to entry: The ratio scale is the only case for which it is meaningful to say that one result is, for instance, ten times as great as another.

3.9**receptor**

<materials testing> substrate used to rub the test specimen and onto which ink or other material that is removed from the specimen is transferred

Note 1 to entry: An example of a receptor is the back side of the printed media (printed or $D_{\min}$ area) being evaluated or a standard reference paper.

3.10**rub resistance**

ability and/or degree of a substrate or a print to withstand rubbing, as evidenced by *abrasion* (3.1) effects

3.11**scuff**

surface mark caused by rubbing or *abrasion* (3.1)

3.12**smudge**

result of rubbing leading to the displacement of colorants into adjacent areas as a result of the re-deposition of abraded material

4 Principle

Depending upon their intended use applications, rub resistance is a desirable and sometimes critical property of prints. The result of rub may be degradation in both image quality and physical properties. This practice can be used to evaluate the abrasion, smudge, and scuff resistance of prints under laboratory conditions.

The key intrinsic property of a print that affects its abrasion resistance is the internal cohesion strength, the loss elastic module, the elastic module, etc. which relates to plastic deformation of the materials that make up the imaging layer of the print. The secondary property in a print that also affects the abrasion resistance is the strength of adhesion between the imaging layer material and its substrate. Finally, the condition of the substrate surface itself (such as sizing, or coating, or porosity) will also impact the abrasion resistance of a print.

This method provides a reasonably simple procedure that can be used to set specifications for prints and determine whether a product meets a predetermined standard for abrasion, smudge, or scuff resistance for a given use application.

NOTE 1 It is not the purpose of this document to define limits of acceptability or failure.

This method utilizes either a reciprocating, a rotating, a combined reciprocating and rotating, or a swing arm rubbing device. The test specimen is placed in contact with a receptor surface under a

specified load and is rubbed with a defined motion at a specified frequency and for a specified number of cycles. In case of a reciprocating device, a cycle consists of 2 strokes, namely forth stroke and back stroke.

The test results are significantly influenced by the pressure applied and the number of rub movements. They may also be influenced by the speed of rubbing. The pressure results from the force applied and the effective contact area determined both by the geometry of the instrument and on the roughness/smoothness of both the print or substrate and receptor, which may change during the test.

During tests particulates may be separated from the print/substrate or from the receptor. If these are trapped between print/substrate and receptor, severe damages to the print/substrate may result.

While test results of devices using the same pressure are comparable, the commercial devices described in [A.1](#), [A.4](#), [A.5](#), and [A.6](#) use different pressures and different rub movements. Test results between test devices with different pressures and different rub movements will not necessarily be the same.

NOTE 2 Different instruments are described in ASTM D 5264^[16], ISO 105-X19, ISO 7784-3, ASTM F 1319^[18], BS 3110^[21], ISO 12947-1 or in [A.6](#).

Results are compared to equivalent, unabraded specimen and receptor. After the test the specimen is removed from the test device and evaluated for degree of degradation by visual assessment, and if appropriate by measuring the change in gloss, optical density, colorimetry, and/or change in physical appearance in both printed and $D_{\min}$ areas.

The receptor is analysed for the amount of colorant or coating transferred from the specimen as evidenced by an increase in optical density or change in colorimetry. For more severe tests, mass differences may also be considered.

NOTE 3 Measuring optical density or colour or using image analysis based on scanner systems is usually insufficient to meet visual rank orders of sample series.

It should be noted that there are several alternative standard test methods that attempt to characterize other degradation aspects of imaging materials due to frictional contact with various surfaces under different loads and geometries. Specifically, the user of this document is directed to ASTM F 1486^[20] (GA-CAT), ASTM D 6037^[17] (Taber), and ASTM F 1478^[19] (Taber). Depending on the specific end-user application, one or more alternative methods may produce a more relevant result.

5 Test device

5.1 Test device description

This document uses test devices¹⁾, such as described in ASTM D 5264, ISO 105 X19, ISO 7784-3, and ASTM F 1319 or in BS 3110, or in ISO 12947-1 or [A.6](#). See [Annex A](#) for a more complete description of the different abrasion testers mentioned in these referenced documents. Equipment that applies a similar reciprocating abrasive force in a similar manner as described in the preceding standards may also be used.

5.2 Test device preparation

The test device shall be set on a stable laboratory bench, in a room conditioned to the desired test temperature and relative humidity. Conditions of $(23 \pm 3) ^\circ\text{C}$ and $(50 \pm 10) \%$ relative humidity shall be used for testing, unless specific product end-use requires different conditions.

1) Examples of test devices are the Sutherland® Rub Tester (Danilee Co.), the AB-3D1 Colour Fastness Rubbing Tester (Tester Sangyo Co., Ltd.), the NUS-ISO 3 (Suga Test Instruments Co., Ltd.), the FR-2 (Suga Test Instruments Co., Ltd.), the TRIBOGear TYPE 32 (Shinto Scientific Co., Ltd.), Martindale (James Heal), RT 4 (IGT or Hanatek), and Quartant (prüfbau). This information is given for the convenience of users of this Document and does not constitute an endorsement by ISO of these products.

6 Samples

6.1 General

Photographic images printed on “photo-grade” media, including coated or surface treated papers shall be tested in accordance with ISO 18947-2.

Samples to be tested may be prints from regular print runs or test prints. Samples may also be prints treated at either side (varnished, laminated, bonded, backed, etc.). Samples shall be of a size appropriate for the test device to be used.

The evaluation of rub on printed receptor surfaces may be difficult. Therefore, standard (unprinted) receptor substrates (recommended for third party evaluation) or backsides of front side printed substrates (to simulate rubbing resistance for real production runs) are recommended.

Samples shall be tested in two directions perpendicular to each other. If there is proof of non-directional rub testing, then testing in one direction is sufficient.

NOTE Samples can show different properties depending on the rub direction. These differences in rub test directions can be caused by fibre orientation, texture or other. Rub resistance tests perpendicular to the fibre direction of graphic prints result in higher rub-off and therefore more reliable evaluation for offset printed samples.

Both the test specimen and the receptor shall be a flat sample with no surface irregularities, such as scoring or creases.

If testing multiple samples, it is important that each has comparable, if not, identical colorant coverage and colorant density. If the purpose of the test is to compare the print technologies, select appropriate substrates and minimize substrate differences whenever possible.

Care shall be taken to avoid contaminating the sample with fingerprints during handling, as this can influence the test results.

6.2 Preparation of samples and selection of the receptor material

The method of printing and handling of printed samples shall be consistent with the anticipated product end use, including the presence of an image overcoat or laminate if the print will generally be supplied with an overcoat or laminate.

Test prints for conventional printing processes shall be uniform and shall be prepared in accordance with the ISO 2834 (all parts) with agreed upon density or colour coordinates. Test prints for digital printing processes including photographic prints may contain special test targets.

Printed samples shall be dried or cured and conditioned to the level of the intended use prior to rub testing. Water based inkjet-printed samples shall be left face-open under the standard environmental condition at least 14 days prior to rub testing. A shorter conditioning time may be agreed upon when the purpose of the test is to evaluate the abrasion resistance at a shorter time after printing. During drying, curing and conditioning dust deposition on the surface to be tested shall be avoided.

Samples and receptor material shall be conditioned at $(23 \pm 3) ^\circ\text{C}$ and $(50 \pm 10) \%$ relative humidity for 24 h or longer. A shorter conditioning time may be agreed upon when the purpose of the test is to evaluate the abrasion resistance at a shorter time after printing.

If tests need to be performed under different climatic conditions, samples also shall be conditioned in this climate and the conditions shall be recorded.

7 Test procedure

The test shall be conducted under environmental conditions of $(23 \pm 3) ^\circ\text{C}$ and at a relative humidity of $(50 \pm 10) \%$. The test procedure for each of the test devices referenced in 5.1, and described in more

detail in [Annex A](#) is slightly different, based on the specific design and capabilities of each of the test devices. The following are the key parameters that need to be controlled and reported relative to the specific test device being used:

- the size of the sample specimen and the dimensions of the printed colour patches;
- the specific receptor material, its fibre direction (if applicable) and the dimensions of the receptor;
NOTE For example, for sheet-fed offset prints a better differentiability was verified if the fibre direction of the abrading paper was perpendicular to the rub test direction.
- the weight or force applied to either the test specimen or receptor;
- the number of rubbing cycles or strokes (one cycle comprises one stroke in each direction);
- the line speed of rubbing (or angular speed, if rubbing is in a circular motion), expressed in mm/s (or °/s).
- the positioning of the rubbing movement across the border of imaged and un-imaged area in order to assess smudge

Test results strongly depend on the type of sample, the type of the test device (with the exception of devices having exactly the same test parameters and conditions) and the parameters of testing. There shall be prior agreement on the test device and test parameters between parties. Devices with both reciprocating and rotating action may require integer multiples of their rotational action (e.g. 16 cycles for a Martindale-Lissajous (see [A.4](#)) or 16 cycles for one full cycle on a device according to [A.6](#) (e.g. a Quartant, see [A.6](#))). If unknown samples are to be investigated, preparatory tests with different parameter settings should be performed to identify test conditions showing a good differentiation of sample series with the aim to identify the optimum set of test parameters. The process of identifying the optimum test parameters shall be documented.

Each rub test shall be repeated at least once. The test may be performed either with or without interruption. If the test is interrupted, it is strongly recommended to have a prior agreement between parties on the design of the test cycles.

NOTE 1 In the process of rubbing the specimen may warm up and/or debris can be formed between the layers under test and the receptor. The interruption of the test can be used for intermediate inspection, cooling of sample and/or removal of debris.

NOTE 2 For prints on matte substrates sometimes one action is sufficient to cause significant rub pattern, whereas varnished prints may require more than 1 000 actions to cause visible rub-off.

8 Evaluation

8.1 General

Visual examination is required. Instrument based measurements can be used instead, if a correlation with visual examination has been proven.

Results obtained under different operating parameters and conditions or with different test devices shall not be directly compared, unless a correlation can be shown for specific settings of different test devices.

8.2 Visual evaluation

Rubbed test prints are evaluated for changes in colour (density) and gloss. Evaluation of colour changes also include lateral transfer of colorant in un-printed areas adjacent to printed areas (smudge). Adjacent areas are $D_{\min}$ areas and rub-tested square shaped areas of the rubbed sample with an edge-length of 20 mm centrally located on a boundary line between printed and $D_{\min}$ areas fully covered by the motion

path of the receptor. Also, receptors are evaluated for colorant transfer, which may appear larger than the visual colour differences of the rubbed prints.

For the evaluation of colorant transfer, typically the receptors are evaluated since the differences of the rubbed prints are smaller than the ones on the receptor. For the evaluation of gloss changes, smudge and any other image quality related change, the prints need to be evaluated.

When receptors are evaluated the endpoints of a possible scaling are 'unrubbed receptor material' on the better side and eventually 'full tone printed areas' on the worse side of a scale. Additional grade samples in between – either prepared independently or out of the range of test results – may be selected to ease visual evaluation and should be agreed upon between the test provider and the customer.

The viewing conditions shall be suitable for evaluation of colour and gloss, which represent two different settings of the observer geometry. For colour evaluation, a diffuse and uniform illumination of the specimens with a white, broadband light source shall be used with an illuminance level exceeding 500 lx in the display zone. Suitable lamp types include tungsten halogen, xenon, metal halide, broadband LED and broadband fluorescent.

NOTE 1 Narrowband light sources with emission lines smaller than the colour matching functions typically introduce stronger metameric effects than broadband light sources and therefore introduce larger variability in the visual evaluation.

Care shall be taken to avoid glare in the visual field of the observer.

For evaluation of physical defects and changes in the gloss, the surface of the specimens should be inspected with oblique directional lighting, while changing the incident and observation angle by means of tilting samples for contrast maximization. More than two observers shall be used to perform the visual evaluation.

The minimum aim of the visual evaluation is the establishment of a rank order by pairwise comparison. The test provider and the customer may agree on more elaborated aims of the visual evaluation, being either an interval scale or a ratio scale^[24].

NOTE 2 Due to different viewing angle contrast behaviour of different rub test samples no reliable correlation between visual and measured optical properties (densitometry, colorimetry, image analysis based on scanner systems) of sample groups could be established^[23].

8.3 Optical measurements

If optical measurements are deemed necessary each specimen shall be examined/measured for degradation using a gloss meter at either a 20°, 60°, 75°, or 85° angle as described in ISO 2813 and ISO 8254-1, as well as with either a densitometer as described in ISO 5-3 and ISO 5-4 or a colorimeter (CIE $L^*a^*b^*$) as described in ISO 13655 with either 0°/45° or 45°/0° geometry.

NOTE Pertinent gloss measurement standards describe the choice of measurement angle as function of the level of gloss of the non-abraded image print.

For gloss, consider directional dependence due to eventual presence of quasi linear abrasive patterns and/or printed substrate texture.

Both the imaged and adjacent $D_{\min}$ areas of the specimen shall be measured. These areas are defined by adjacent squares with an edge-length of 20 mm or the width of the receptor, whatever is smaller, centrally located on a boundary line between printed and $D_{\min}$ areas fully covered by the motion path of the receptor. In each square area, five measurements are taken at positions that are arranged as the dot pattern that represents an "x-pattern" like the number "5" on a dice (see also ISO 18947-2:—, Figure B.1). Optionally, each corresponding receptor may be measured for densitometric or colorimetric change, due to transfer of colorant from the specimen. In cases in which non-uniform wear patterns are observed, at least five separate measurements randomly selected within the treated area shall be made and averaged so as to obtain a representative result. In any event, a minimum of five measurements per sample shall be taken and averaged. Each specimen shall also be inspected visually, and visible

degradation not accounted for by changes in gloss or optical density or colour shall also be noted. In the case of samples with a directionality, these shall be measured in both directions.

9 Test report

For each sample tested, the user of this document shall report the following parameters, conditions, and results:

- a) a reference to this document, i.e. ISO 18947-1:2021;
- b) the nature of the samples including (if known) printing process, substrate type, ink type, and product name of the ink. For test prints the printer settings, printed test image density, and materials used to make the test specimen (in the case of analogue test specimens, the process used to make the print);
- c) the test device used to perform the test, including model number, manufacturer, and any unique modifications that have been made;
- d) the dimensions of the test specimen, the individual colour patches, and the receptor;
- e) a precise description of the receptor material;
- f) the weight or force applied to the receptor and test specimen;
- g) the total number of cycles, the rate of cycling, the line speed (or angular speed), and the direction of the motion against any fibre or texture direction of the image sample and the receptor (perpendicular or parallel);
- h) the visual rank order of the samples and the number of individuals delivering rankings;

and if instrumental evaluation were performed in addition:

- i) the specific instruments and pertinent geometries, illuminants, and filters used to measure density, colour, and gloss if applicable;
- j) abrasion resistance in terms of the change in colour, optical density or gloss of each sample (or each patch) if applicable;
- k) smudge resistance in terms of the change in colour or optical density of the unprinted area adjacent to each of the colour patches if optical measurements were performed;
- l) colorant transfer in terms of the change in optical density or colour of the receptor if optical measurements were performed;
- m) scuff in terms of the change in gloss if gloss measurements were performed.

The institution and/or organization responsible for the results reports the following in addition:

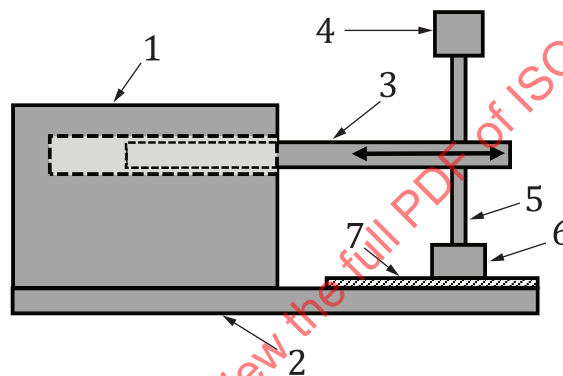
- n) the location and date of the test and its climatic conditions;
- o) the person, institute, and/or organization responsible for the report.

Annex A (informative)

Examples of test equipment and corresponding procedures and operating parameters

A.1 Linear reciprocal flat rub tester (ASTM D 5264)

A flat sample specimen is rubbed with a flat abrasion head. The force is uniformly applied across the abrader, and the abrader or the sample moves linearly, as shown in [Figure A.1](#) or quasi-linear, as shown in [Figure A.2](#), with a specific constant speed back and forth.



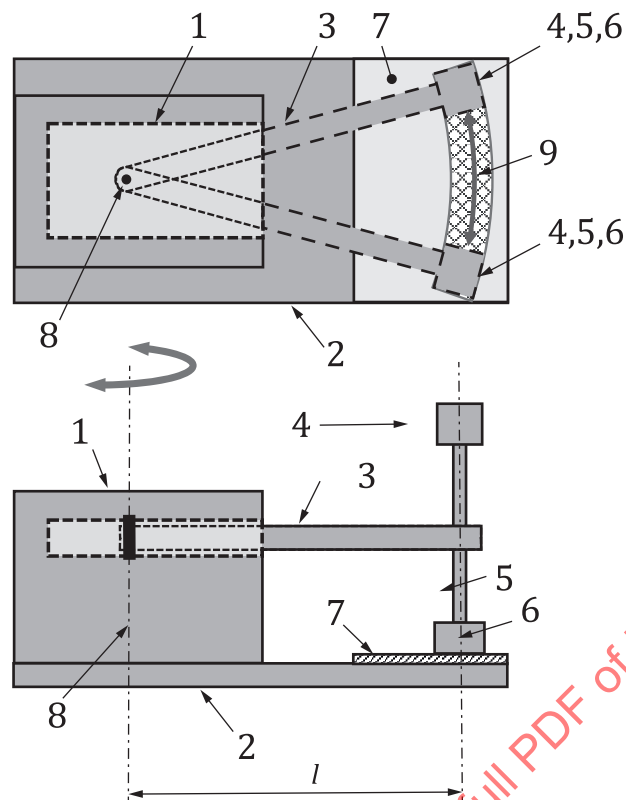
Key

- 1 motor controller
- 2 base
- 3 reciprocating arm
- 4 normal force weight
- 5 adjustable height rod
- 6 abrasive pad and holder
- 7 specimen

Note: During the test, the reciprocating arm moves according to the double sided arrow and reciprocates the abrasive pad and the holder relative to the specimen.

Figure A.1 — Conceptual diagram of the linear flat abrader

The test device described in ASTM D 5264 is depicted in [Figures A.2](#) and [A.3](#).



Key

- 1 motor with a driver for a reciprocating swing motion
- 2 base
- 3 swinging arm
- 4 normal force weight
- 5 adjustable height rod
- 6 abrasive pad and holder
- 7 specimen
- 8 turning axis of the swinging arm
- 9 arc segment of quasi-linear motion

Note: The swinging arm (3) moves back and forth around a vertical turning axis (8) which resides within the motor block (1), sweeping a small angular sector (typically 10° to 15°). The abrasive pad and holder is attached to the swinging arm at distance l from the axis and describes an arc with a defined reciprocation stroke length.

Figure A.2 — Conceptual diagram of a swinging arm tester: top view (up) and side view (down)

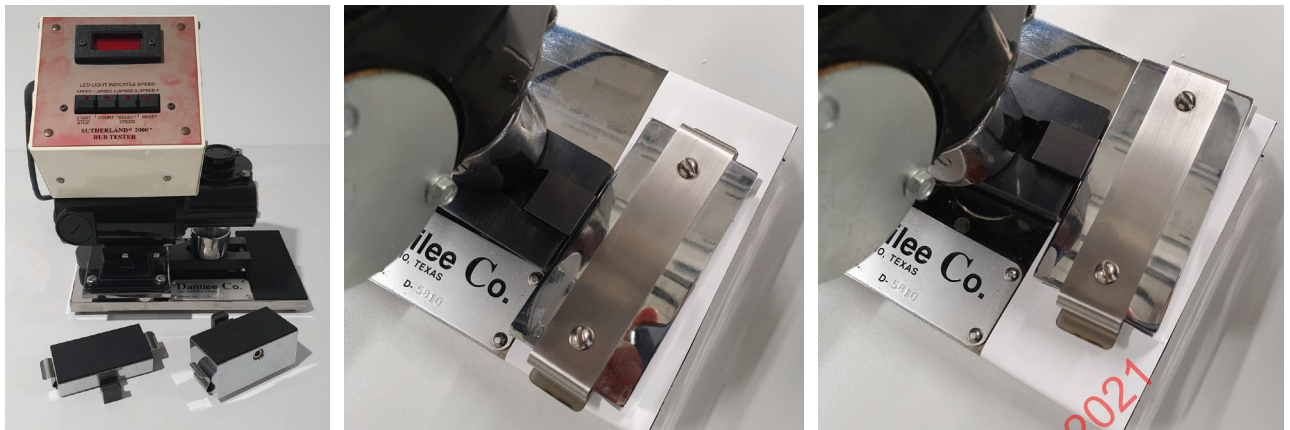


Figure A.3 — Sutherland rub testing apparatus described in ASTM D 5264 (left) together with test movement on the Sutherland rub testing apparatus (middle and right)

The examples of test devices are described in IEC 63211-3-5^[14] and ASTM D 5264.

The followings are the key parameters;

- a) force (N/cm²),
- b) line speed (cm/s),
- c) frequency (cycles/min), and
- d) number of rubbing cycles.

According to the referenced ASTM standards, when this type of instrument is used, the following procedure and key parameters are typical:

A rubber pad, 76 mm by 152 mm, is mounted on top of the test device base and to the bottom face of the receptor block. The pad face should be uniformly flat (level) with a Shore A hardness of 15 ± 5 as measured with a durometer according to ASTM D 2240^[15].

NOTE 1 This pad will need periodic replacing as the rubber becomes brittle due to oxidation or if the rubber wears off the pad. This periodic replacing is also true of the pads that come with the test device receptor weight. Failure to replace worn pads could result in distorted test results.

The test specimen is cut to 76 mm × 152 mm and is mounted on top of the rubber pad on the test device base, and the receptor is cut to fit either the 0,91 kg or the 1,81 kg weight (depending on which one is being used). The receptor is mounted to the weight. Receptors cut to a 178 mm length (51 mm width) can be held in place by the clamps on the sides of the block, while shorter receptors (minimum of 102 mm length) can be held in place by pressure-sensitive double-sided tape. The specimen and receptor should be lightly brushed with a soft natural hair brush to remove any potentially abrasive contaminants from the surfaces. A vacuum cleaner fitted with a soft nylon brush may also be used to remove contaminants from the surface.

The weight is mounted on the test device and the machine is turned on. The specimen is rubbed in increments of either 10 or 50 cycles (100 strokes) at a rate of 43 cycles/min along a 57 mm path, where one cycle is one back-and-forth stroke. The number of cycles is typically preset on the device control panel.

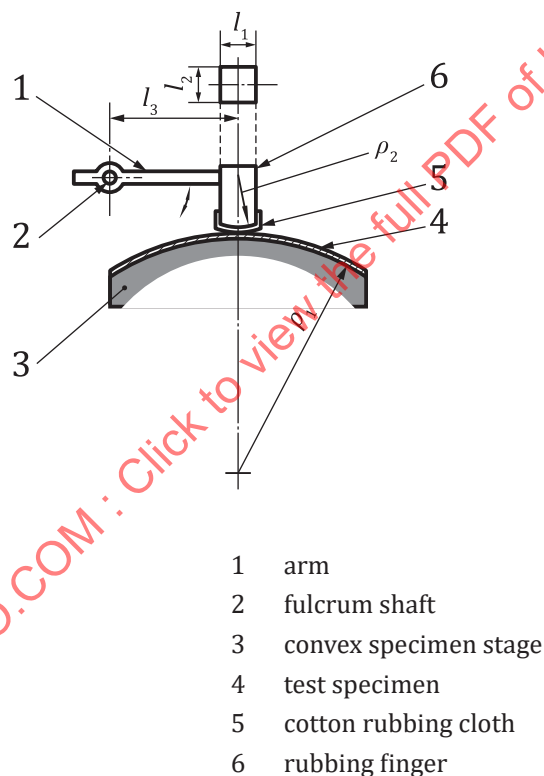
NOTE 2 Examples of testing conditions that provide good differentiation between sheet fed offset samples are: 910 g test weight, 21 cycles/min test speed, 16 strokes against mat paper and 1 810 g test weight, 21 cycles/min test speed, 16 strokes against glossy paper^[23].

A.2 Linear reciprocal curved rub tester (ISO 105-X19)

The rubbing tester which is described in ISO 105-X19 consists of a curved sample stage and rubbing finger in conjunction with a forcing arm. (See Figures A.4 and A.5). The rubbing finger has a curved surface of 45 mm surface radius, and it is approximately 20 mm long and 20 mm wide, capable of affixing a receptor (e.g. a standard reference paper, the face or back side of an unprinted piece of the sample paper, or a cloth, such as un-dyed cotton cloth). The contact area between the sample and receptor is approximately 100 mm². One end of the forcing arm is on a fixed axis, and a force is exerted on the rubbing finger at the other end. The curved specimen stage has a 200 mm surface radius, is capable of reciprocating horizontally at a speed of 30 reciprocations per minute along a 120 mm track, and is capable of reciprocating the rubbing finger in a 100 mm track.

When this type of instrument is used, the following procedure and key parameters are typical:

The test specimen is mounted on the stage, and the abrasive receptor is attached to the tip of the rubbing finger. The rubbing meter is started for 50 cycles at a speed of 30 cycles/min along a 100 mm track on the specimen exerting a force of 2 N (approximately 200 g). The force and number of reciprocations can be varied and will depend on the type of materials and the intended application.

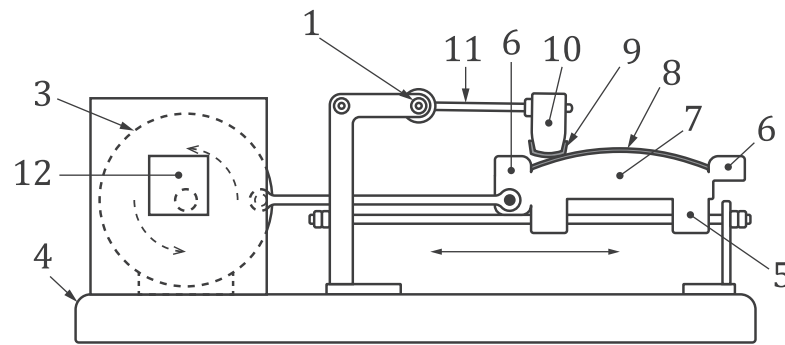


Key

l_1	(20 ± 0,5) mm
l_2	20 mm
l_3	110 mm
ρ_1	200 mm
ρ_2	45 mm

1	arm
2	fulcrum shaft
3	convex specimen stage
4	test specimen
5	cotton rubbing cloth
6	rubbing finger

Figure A.4 — Detail of rubbing tester

**Key**

1	fulcrum shaft	7	convex specimen stage
2	(empty)	8	test specimen
3	motor with crank wheel	9	cotton rubbing cloth
4	base	10	rubbing finger
5	horizontal moving device	11	arm
6	clamp for test specimen	12	cycle counter

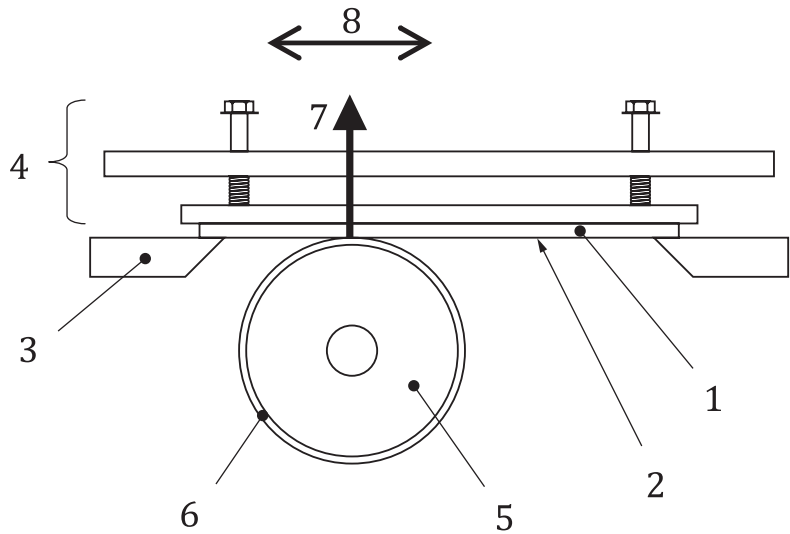
Figure A.5 — Rubbing tester**A.3 Abrasion tester (ISO 7784-3)**

The abrasion tester that is described in ISO 7784-3 consists of a clamping device or pressure plate for holding the test specimen level and rigid, and a 50 mm $\pm$ 0,05 mm diameter wheel, to the outer circumference of which is attached a 12 mm wide strip of abrasive receptor (e.g. paper). (See [Fig A.6](#).)

The force between the wheel and the test surface is capable of being varied from zero to at least 6,9 N $\pm$ 0,05 N. The abrasive action is produced by rubbing a test panel in a reciprocating manner (stroke length 30 mm) against a stationary wheel. After each double stroke (one cycle), the wheel is advanced through a small angle to bring a fresh area of the abrasive receptor into contact with the test surface before making the next double stroke. The angle of rotation is such that, after 200 cycles (400 strokes), the wheel will have made one complete revolution. On completion of this cycle, the abrasive receptor should be replaced. The frequency of motion of the test panel is typically 40 cycles/min. The number of cycles may be registered by means of a counter, and provision is normally made for the apparatus to switch off automatically after a preset number of cycles has been reached (200 cycles maximum).

When this type of instrument is used, the following procedure and key parameters are typical:

The test specimen is mounted on the specimen stage. The receptor is 12 mm wide, and the length is such that it covers the circumference of the abrasive wheel without any overlap or gap at the ends (a strip length of 157 mm should be sufficient). The receptor is attached to the circumference of the wheel with double-sided adhesive tape. The specimen stage is reciprocated 50 times at a frequency of 40 cycles/mm along a 30 mm track. The pressure applied to the specimen by the wheel is set between 0,98 N and 29,42 N.



Key	
1	test specimen
2	surface of the test specimen
3	test specimen stage
4	test specimen fixed device
5	wheel
6	abrasive paper
7	load
8	reciprocating motion of test specimen stage and test specimen

Figure A.6 — Abrasion tester

A.4 Martindale abrasion testing apparatus (ISO 12947-1)

The testing machine referred to in this document is fully defined in ISO 12947-1 and is depicted in [Figure A.7](#).



Figure A.7 — Martindale abrasion testing apparatus

The Martindale method was originally created in the 1950’s to determine the abrasion resistance of fabrics. Since then, the method has been adopted to determine the abrasion resistance of wood and high pressure laminates and the scratch resistance of paints, lacquers and automotive interior components with high gloss finishes.

The machine consists of a base plate with a number of sample holding stations. [Figure A.7](#) shows a five station Martindale. Above the base plate is a moving top plate with a motion that describes either a Lissajous pattern shown in [Figure A.8](#) or a reciprocate pattern.